Indicator: Land Use (325)

(Note: Some, but not all of these data sources revise their estimates annually – between Dec 2004 and the publication of the ROE, numbers may be updated and reported trends may change.)

Land use is one of the most visible effects of human inhabitation of the planet and can have effects on both human health and ecological systems. For example, land use changes may affect the potential of land to erode, the condition or contiguity of habitat, the hydrologic characteristics of a watershed, or the spread of vector-borne diseases.

This indicator tracks trends in area associated with a number of the most important land uses over the period 1977 – 2002 using a number of different data sources. These sources do not always represent the same time frame, sample the same resource or geography, or use the same definitions.

The National Resources Inventory (NRI) conducted by the USDA Natural Resources Conservation Service was used to track trends in "crop and pasture" and "developed" land (residential, commercial, industrial, and transportation uses). Between 1977 and 1997 the NRI developed estimates every five years on non-federal lands in the contiguous U.S. Since 2001 NRI has developed annual estimates, based on a smaller sample size. NRI does not address federal lands (representing 647 million out of 2.3 billion acres). Because relatively little agricultural and urban development occur on federal lands, however, the NRI data likely offer a reasonable approximation of national trends in these categories.

The Forest Inventory Analysis (FIA) surveys conducted by the USDA Forest Service were used to track trends in forest and timberlands. FIA surveys include both private and public land in all states. The FIA typically assesses timberland acreage every ten years.

The USDA National Agricultural Statistical Service (NASS) Census of Agriculture was used to track trends in the extent of "crop and pasture" land and "farm rangeland" (typically "improved" pasture). NASS data are available only for 1997 and 2002. The USDA Economic Research Service (ERS) has data on the extent grass and forested rangeland (typically unimproved grazing land) for 1997 only.

What the Data Show

Crop and farm rangeland has declined since 1997, developed land has increased, and timberland has remained approximately constant (Figure 325-1). The remaining categories have too few years of data to establish a trend. As of 2002, based on both NRI data for cropland and pastureland and NASS data for cropland and pastureland on farms, 19-21% of the land in the U.S. was used for crop production. NRI row crops, orchards, and pasture declined by nearly 66 million acres (12%) between 1982 and 2002, and by 10 million additional acres (2%) between 1997 and 2002. According to the NASS estimate, the amount of land in farms in 2002 as 938 million acres, about 2% less acreage than in 1997 (955 million acres), and the number of farms decline by 87,000. Of the land in farms in 2002, approximately 434 million acres were harvested cropland or cropland used for pasture/grazing (the remainder includes woodlands, buildings, and other non-crop pasture). Of this 434 million acres, slightly more than half a million acres were used to produce organic crops.
Based on NRI data, in 2002 nearly five percent of the country was considered developed, increasing by 34.5 million acres since 1982, or 47%.

In 2001, lands supporting timber production comprised approximately 22% of the U.S. While forestland is a land *cover* classification, "timberland" is a land *use* classification that reflects forestland capable of producing at least 20 cubic feet per acre per year of industrial wood and not withdrawn from timber utilization by statute or regulation. Two-thirds of the 749 million acres of U.S. forestland, or 504 million

acres, qualified as timberland in 2001, 10 percent or 77 million acres of forest land were reserved, and the remainder, 168 million acres were characterized as unproductive. Since 1952, the variation between the maximum and minimum area of timberland has been approximately 30 million acres, or roughly 6% of the total. Between 1987 and 2001, timberland acreage increased nearly 19 million acres. This increase is attributed to a combination of tree planting done under the Conservation Reserve Program and reclassification of some National Forest lands to align with classifications used on other land ownerships.

The NASS estimates that grazing and range use on lands considered farms declined by less than 1% to 395 million acres in 2002. The broader ERS estimate of rangeland use, including grassland and shrubland pasture and grazed forestlands, indicates that nearly a third of the U.S. fell into this land use in 1997.

Land use varies substantially by EPA Region (Figure 325-2). The data range from 1997 to 2002, depending on the source of the data. Grazing and rangelands in Regions 6, 8, and 9 represent more than three-quarters of the total nationwide, while Region 4 holds the largest portion (27%) of timberland. Trends also vary widely among regions (Figure 235-3). Nearly 84% of the cropland lost between 1987 and 1997 was in Regions 4 through 8. Although increases in developed land are responsible for part of this decline (e.g., developed land nearly doubled in between 1982 and 1997 in Region 4), much of it can be attributed to the federal Conservation Reserve Program (CRP), established by the Food Security Act of 1985 to assist private landowners in converting highly erodable cropland to vegetative cover for 10 years. Since 1985, 31.6 million acres of former cropland have been enrolled in CRP, potentially accounting for as much as 60% of the loss of cropland from 1985 to 1997.

Protecting lands for certain uses is a form of land use. A Conservation Biology Institute/ World Wildlife Fund study found that about 5.0% of land mass in the US is strictly protected (GAP 1), and another 5.3% in slightly more relaxed types of protection (GAP 2). These results include Alaska, which has more than 35% of its land in GAP 1 or GAP 2. Only 5.1% of the conterminous United States is protected in areas classified as GAP 1 or 2, and most occurs in the Western States (http://www.gap.uidaho.edu/default.htm).

Indicator Limitations

- Estimates have been derived from a variety of inventories and samples, taken in different time frames and for different purposes, limiting the ability to integrate and track changes over time.
- NRI only includes a breakdown by land use type for non-federal land, while federal land accounts for more than 20% of total land in the contiguous United States, and can contain many of the same land uses as non-federal land.
- Changes in NRI sampling design currently limit the amount of sub-national data available (e.g., estimates are not available for states in the 2001-2002 timeframe, as they have been previously in five-year increments: 1982, 1987, 1992, 1997)
- GAP data are largely unavailable for private, county, and city lands, so the Protected Areas Database is largely an assessment of protected state and federal lands.
- Some land uses may not be physically visible, but only designated administratively (e.g., lands that are reserved for parks or wilderness may appear similar to lands that are managed for natural resources).
- Land use designations and management are most frequently managed and monitored by local governments in the U.S., each using different approaches and classifications making national summaries difficult.
- The extent of lands used for energy production, resource extraction or mining is not known and represents a significant data gap.
- Lands specifically protected for certain uses such as wilderness or parks, have been periodically inventoried for the nation. These statistics are currently not reported in a form that allows comparison with other statistics.

Data Sources

Conservation Biology Institute, Protected Areas Database, Second Edition. (A recently updated Third Edition is available online at http://www.consbio.org/cbi/applied_research/pad_2005/pad2005.htm).

The H. John Heinz III Center for Science, Economics and the Environment. *The State of the Nation's Ecosystems*. 2002. http://www.heinzctr.org/ecosystems/urban/imprv_area.shtml.

USDA Natural Resources Conservation Service, National Resource Inventory http://www.nrcs.usda.gov/technical/NRI/.

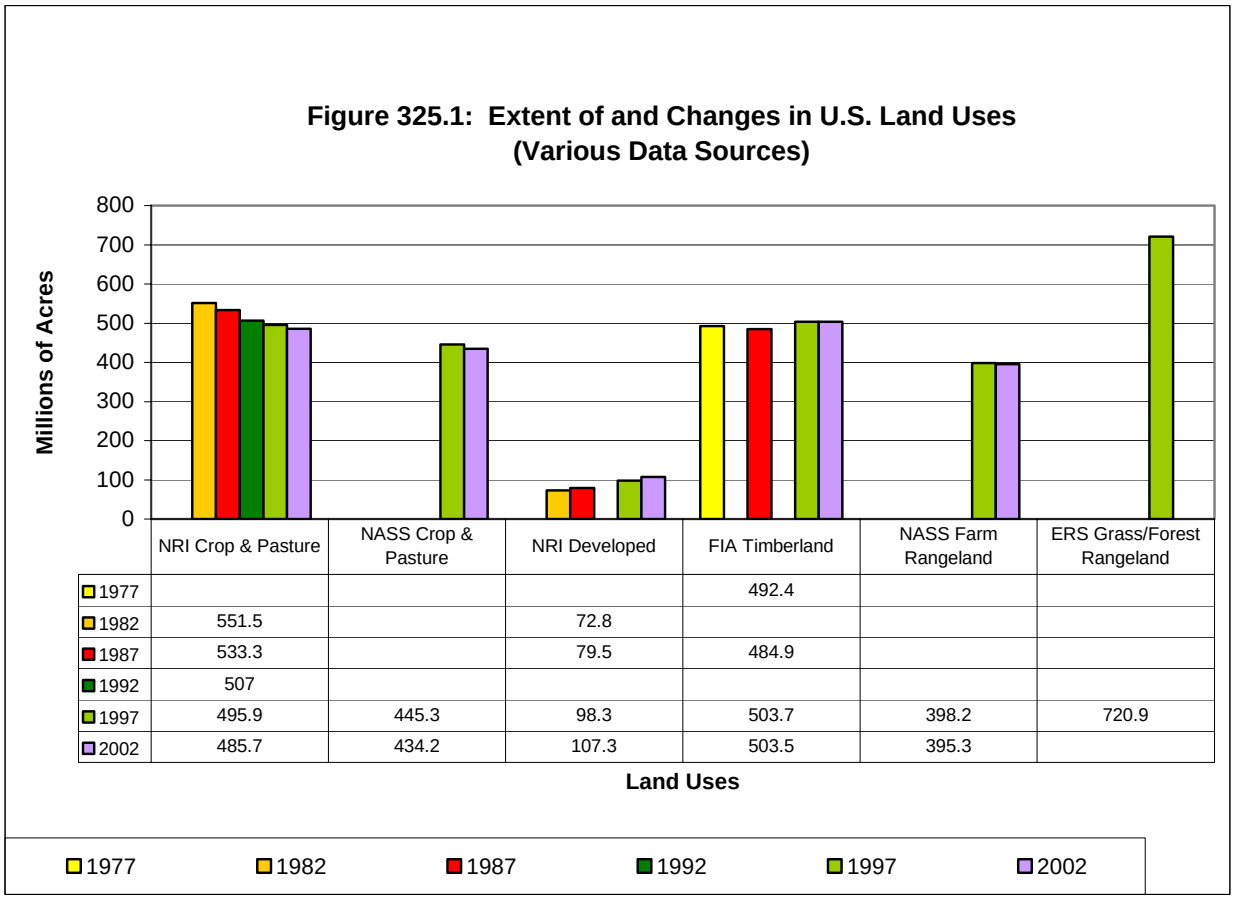
USDA, 2000. *Summary Report: 1997 NRI (Revised December 2000)*, Natural Resources Conservation Service, Washington, DC, and Statistical Laboratory, Iowa State University, Ames, Iowa, 89 pp.

USDA, National Agricultural Statistical Service, 2002 Census of Agriculture, June 2004 http://www.nass.usda.gov/census/census02/volume1/us/us2appxc.pdf (QA/QC) http://www.nass.usda.gov/census/census02/volume1/USVolume104.pdf.

USDA Forest Service, Forest Inventory Analysis (http://www.fia.fs.fed.us). FIA Data is included in the *Forest Resources of the United States,2002*. http://ncrs.fs.fed.us/pubs/gtr/gtr_nc241.pdf.

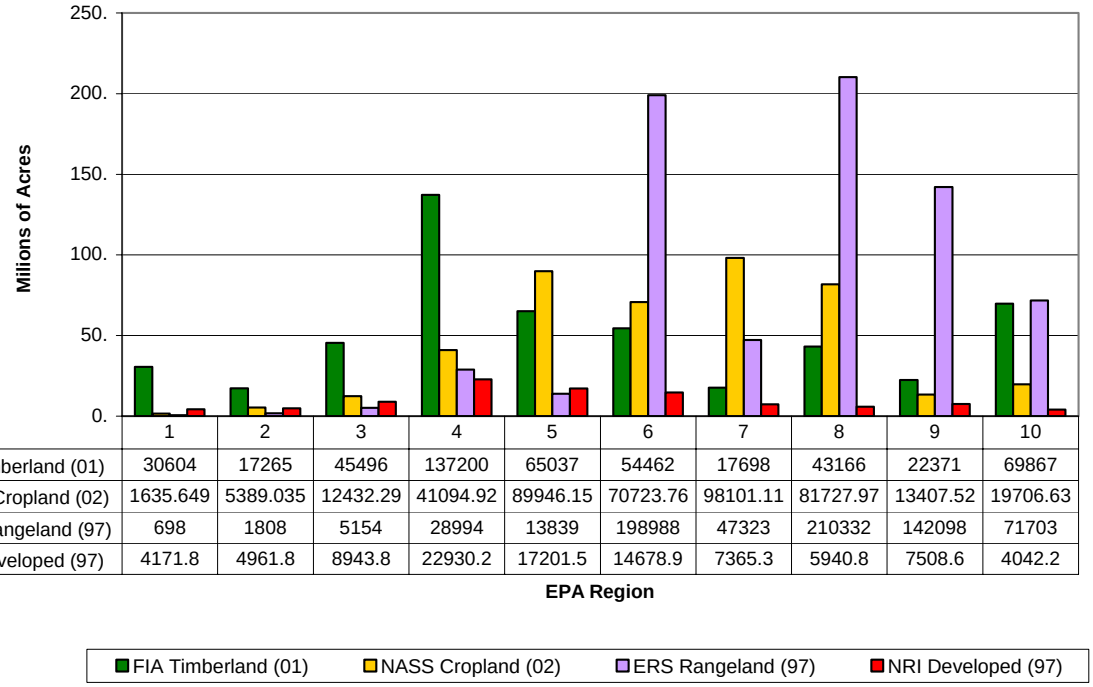
USDA, Economic Research Service; Major Uses of Land in the United States, 1997 Marlow Vesterby and Kenneth S. Krupa, Statistical Bulletin No. (SB973) 60 pp, September 2001. http://www.ers.usda.gov/publications/sb973/sb973.pdf.

Graphics



	NRI Crop & Pasture	NASS Crop & Pasture	NRI Developed	FIA Timberland	NASS Farm Rangeland	ERS Grass/Forest Rangeland
1977				492.4		
1982	551.5		72.8			
1987	533.3		79.5	484.9		
1992	507					
1997	495.9	445.3	98.3	503.7	398.2	720.9
2002	485.7	434.2	107.3	503.5	395.3	

Figure 325.2: Land Use within EPA Regions

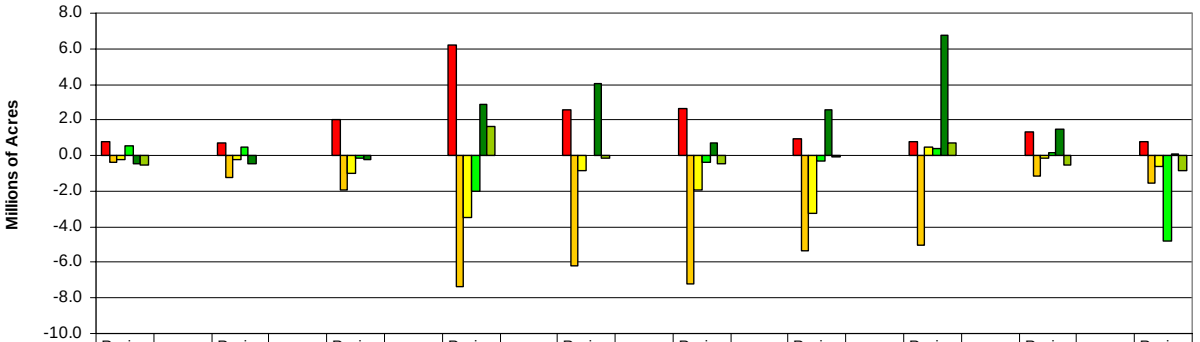


	1	2	3	4	5	6	7	8	9	10
FIA Timberland (01)	30604	17265	45496	137200	65037	54462	17698	43166	22371	69867
NASS Cropland (02)	1635.649	5389.035	12432.29	41094.92	89946.15	70723.76	98101.11	81727.97	13407.52	19706.63
ERS Rangeland (97)	698	1808	5154	28994	13839	198988	47323	210332	142098	71703
NRI Developed (97)	4171.8	4961.8	8943.8	22930.2	17201.5	14678.9	7365.3	5940.8	7508.6	4042.2

EPA Region

FIA Timberland (01) NASS Cropland (02) ERS Rangeland (97) NRI Developed (97)

Figure 325.3a: Acreage Change in Land Use by EPA Region

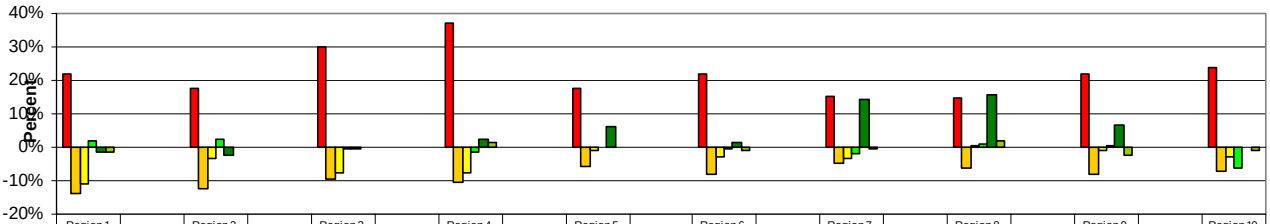


	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
NRI Developed (87-97)	752.4	736.9	2063.2	6235.9	2557.4	2615.7	967.5	763.2	1359.4	774.4
NRI Crop & Pasture (87-97)	-393.4	-1241.8	-1918.5	-7389	-6210.8	-7206.8	-5308.3	-5018.8	-1167.8	-1544.5
NASS Crop & Pasture (97-02)	-202.25	-185.42	-1011.8	-3491.4	-835.88	-1952.5	-3236.3	500.05	-149.49	-594.68
FIA Timber (77-87)	570	450	-117	-1993	-7	-359	-330	387	141	-4784
FIA Timber (87-97)	-455	-442	-240	2916	4026	692	2545	6761	1472	73
FIA Timber (97-01)	-496	-5	-25	1631	-118	-456	-46	733	-523	-818

EPA Region

NRI Developed (87-97) | NRI Crop & Pasture (87-97) | NASS Crop & Pasture (97-02) | FIA Timber (77-87) | FIA Timber (87-97) | FIA Timber (97-01)

Figure 325.3b: Percent Change in Land Use by EPA Region



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
NRI Developed (87-97)	0.2200386	0.1744183	0.2998576	0.3735347	0.1746369	0.216833	0.1512239	0.1474042	0.2210694	0.236979
NRI Crop & Pasture (87-97)	-0.13749	-0.1231932	-0.0952539	-0.1063896	-0.0561446	-0.0792959	-0.0487421	-0.0595455	-0.082523	-0.0703699
NASS Crop & Pasture (97-02)	-0.1100427	-0.0332628	-0.075258	-0.0783072	-0.0092076	-0.0268663	-0.0319363	0.0061561	-0.0110265	-0.0292926
FIA Timber (77-87)	0.018396	0.0260688	-0.0025295	-0.0148018	-0.0001145	-0.0065769	-0.0212506	0.0109678	0.0066256	-0.0634516
FIA Timber (87-97)	-0.0146302	-0.0255935	-0.0052291	0.0215093	0.0617911	0.0126006	0.1434288	0.1593335	0.0642963	0.0010328
FIA Timber (97-01)	-0.0159486	-0.0002895	-0.0005447	0.0120308	-0.0018111	-0.0083033	-0.0025924	0.0172743	-0.0228444	-0.0115725

EPA Region

NRI Developed (87-97) | NRI Crop & Pasture (87-97) | NASS Crop & Pasture (97-02)
FIA Timber (77-87) | FIA Timber (87-97) | FIA Timber (97-01)

R.O.E. Indicator QA/QC

Data Set Name: LAND USE
Indicator Number: 325 (89168)
Data Set Source: NRI (see below), FIA (see #108), NASS (see # 063), ERS (see below)
Data Collection Date: Varies (1977-2002)
Data Collection Frequency: Varies (1 yr, 5 yrs)
Data Set Description: Extent and Trends in Land Use
Primary ROE Question: What are the trends in land use and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The Natural Resources Inventory (NRI) generates estimates, in million of acres, of the amount of nonfederal land in the United States. Nonfederal land includes land that is either privately owned, or managed by Native American tribes, in a trust, or by a state or local government. In 2002, this estimate was approximately 1.49 billion acres. Comparing the data from 2002 to previous data (NRIs were conducted in 1982, 1987, 1992, and 1997) allows for comparisons that establish trends in non-federal land use in the United States. With the advent of the annual NRI, yearly trends and changes will be able to be generated in the future. Uncertainty measurements for the 2002 NRI have yet to be calculated, as the national estimates were based on a smaller sampling size than previous NRIs and state by state estimates have not been concluded yet. In 1997, the NRI estimated that there were 98.3 million acres of developed land, with an estimated margin error of 884,000 acres, or less than 1% at the 95% confidence interval. For cultivated cropland, the total national estimate was 326.8 million acres, with a margin of error of 1.8 million acres, or about 0.5% at the 95% confidence interval.. Uncertainty thus depends on the category of land use, and the geography of the land that is computed. Further details on the current study methodology are available on the NRI website: http://www.nrcs.usda.gov/technical/land/nri02/) For ERS: Data are from: USDA, ERS. 2001. Major Uses of Land in the United States, 1997. Statistical Bulletin No. 973. Table 10: Pasture and range, by type and region, 1997 and Appendix table 3: Pasture and range, by region and State, 1997. http://www.ers.usda.gov/publications/sb973/ The ERS data are estimates based on composites of several published and unpublished data sources. Published sources are: " BLM, Public Land Statistics: 1997. Vol.182. BLM/BC/ST-99/001+1165 " Forest Service, Forest Inventory and Analysis Resources Planning Act (RPA) Assessment Database Retrieval System (1997) " Forest Service, Report of the Forest Service: Fiscal Year 1997 " NASS, 1997 Census of Agriculture. Vol. 1: Part 51, Chapt. 2, AC97-A-51. " NRCS, Summary Report, 1997 National Resources Inventory (revised, December 2000) Unpublished data sources used are cited but not described in the ERS document. The 1997 publication noted above claims: “ERS remains the only source of consistent major land use estimates for all 50 States.” (pg. ii, http://www.ers.usda.gov/publications/sb973/)

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The sampling and monitoring plan for previous NRI data is based on sound scientific principles. Approximately 800,000 total sample sites in every county of every state in the country were included, and cross-indexed data gathering, instructions, and survey instruments were developed

to foster consistent data gathering standards, practices, and procedures. USDA is currently transitioning to a fully implemented annual NRI, with reliability levels approaching those of the 1997 NRI. State and regional estimates have yet to be released, and national estimates were based on much smaller sampling size. Until reliability levels approach those of previous surveys, differences in methodology and reliability must be accounted for. Differences in methodology between 97/02 can be viewed at http://www.nrcs.usda.gov/technical/NRI/1997/data_gathering.html ERS data are based on various published and unpublished data, including NRI, NASS, BLM, USFS, and NRCS. Sampling schema vary in all cases. ERS states: "ERS has been a source of major land use estimates in the United States for over 50 years, and the related U.S. cropland series dates back to 1910. The major land use (MLU) series is the only consistent accounting of all major uses of public and private land in the United States. The consistent series was started in 1945, and has since been published every 5 years, coinciding with the Census of Agriculture. It contains acreage estimates of major uses by region and States for each census of agriculture year from 1945 through 1997. Data from all 12 Major Land Use reports have been combined into a set of files showing major land uses from 1945 to 1997. Gaps in continuity (identified as "Not available") occur only in categories with no data on which to base an estimate. This is the case in Alaska and Hawaii prior to statehood in 1959-1960. Since Alaska contains such vast acreage, 50-State totals in all categories prior to 1959 may appear to change precipitously."

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

There is no specific conceptual model for NRI or ERS – they are compilations of acreages gathered through various inventory efforts to track land use.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NRI uses a stratified two-stage unequal probability area sample to ensure that sample sites are located in all counties and parishes of the 50 states and in Puerto Rico, the Virgin Islands, the District of Columbia, and selected portions of the Pacific Basin. The primary sample unit, or PSU, is the area or segment of land, from which one or more points are selected. In 1997, data was gathered from approximately 800,000 points in 300,000 PSUs. As mentioned earlier, the methodology has been changed in an attempt to expedite the generation of national estimates. 2002 NRI data was collected from 150,000 sampling sites between July 2002 and March 2003. http://www.nrcs.usda.gov/technical/land/nri02/ For ERS: Definitions of rangeland can vary across the underlying data sources used. ERS states that the "major land use series is the only consistent accounting of all major uses of land in the United States, public and private." "A consistent series was started in 1945, and has since been published at intervals coinciding with the periodic censuses of agriculture."

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The NRI and ERS data do not specifically address sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Statistical reliability and methodology of the 1997 NRI is available at (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/appendices1.html), while changes in methodology and reliability for the annual NRIs can be viewed at http://www.nrcs.usda.gov/technical/land/nri02/. The most notable difference that is documented is the change in the number of sampling sites that are included, a decrease of nearly 75%. The precision of NRI estimates depends upon the number of samples within the region of interest, the distribution of the resource characteristics across the region, the sampling procedure, and the statistical estimation techniques. There are some limited descriptions of ERS data sources and approaches in the publication describing land use trends, but no details on statistical sampling procedures. (see: http://www.ers.usda.gov/publications/sb973/sb973.pdf)

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Complete NRI data files are not available on the website, but can be obtained on CD-ROM (for the 1982-1997 NRIs) from the USDA (see http://www.nrcs.usda.gov/technical/NRI/1997/obtain_data.html). The processing fee is $50. What data are available can be accessed via: http://www.nrcs.usda.gov/technical/NRI/ ERS - data tables can be downloaded at http://www.ers.usda.gov/data/majorlanduses/

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The survey design and description of the NRI is clear and complete, including the difference in data sources and methodology that have occurred since the shift to the annual NRI. The statistical design, data gathering, and estimation procedures are all available on the NRI website (http://www.nrcs.usda.gov/technical/NRI/). ERS: The methodology used by ERS to derive its published estimates from the various sources is not described.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The appendices of the 1997 NRI are readily available on the NRI website (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/) and discuss issues related to reliability, as well as protocols for quality assurance and control. ERS: No documentation described for ERS methodology, although some data sources are described elsewhere (e.g., NASS).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The 1997 NRI was based on 800,000 sample sites, in every county of every state in the country, in an attempt to generate an accurate picture of land use/land cover at a state and national level. Annual NRIs compiled since 2000 have been based on a subset of approximately 150,000 to 200,000 sample sites, but starting in 2005, it is anticipated that the annual NRI will approach the reliability of the 1982 through 1997 Five-Year NRIs. Generalization is still possible, but the margin of error in national estimates has gone up, and margins of error for state estimates are not

yet available. ERS: Details unknown about extrapolations, other than for data sets described elsewhere (NASS).

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

For the 1997 NRI and prior data, uncertainty measurements are included in the appendices to the reports. The margin of error for the 1997 annual NRI was approximately twice the estimated standard error, and could be used to construct a 95 percent confidence interval for most states. http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/appendices1.html ERS: No

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Possibly, the amount of developed and agricultural land is based on NRI data. Until 1997, data were generated from approximately 800,000 sample sites throughout the country. However, the 2002 annual NRI is based on 150,000 sample sites, as a smaller sample was needed to allow for more timely reporting of results. Reliability levels for the annual NRIs (national and state level data) are not expected to approach those of the 1997 Five-Year NRI until 2005. http://www.nrcs.usda.gov/technical/land/nri02/) ERS: unknown

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The NRI is a statistical survey of land use and natural resources trends on U.S. non-federal lands. The 2002 NRI estimates that about 401.9 million acres in the contiguous United States are federal land, more than 20% of the 1.9 billion contiguous acres. Lack of data for Alaska and the District of Columbia are also limiting. The shift in sampling size between the 1997 NRI and recent annual NRIs might impact the strength of the conclusions that can be drawn in trying to establish trends over the year. However, while statistical reliability has decreased, the results are still statistically valid at a high level of certainty ERS: there are gaps in the ERS data, but they are difficult to identify specifically given the lack of detail on exact origins of the data used to estimate rangeland. They are a summary of data available nationally, and appear to be the best data available.